Name: _____ Date: _____

Gizmo Activity: Experimental Investigations

[Note: This activity requires you to use the Growing Plants *Gizmo™. This activity was designed as a follow-up to the* Descriptive Investigations *and* Comparative Investigations Gizmo Activities.*]*

Learning goals
After completing this activity, you will be able to …

- Ask a question and write a hypothesis.
- Identify the manipulated variable in a controlled experiment.
- Design a controlled experiment to test the hypothesis.
- Explain the importance of conducting multiple trials.
- Present data using graphs and tables.
- Draw conclusions based on data.

Vocabulary: control group, controlled experiment, experimental group, experimental investigation, manipulated variable, mean, sample size, trial

Warm-up questions (Do these BEFORE using the Gizmo.)
Robert heard from a friend that listening to classical music while studying could help his memory. Before his next social studies test, he studied while listening to Mozart.

On the test, Robert scored 5 points higher than he did on his previous social studies test. Robert decided that classical music helped him study more effectively.

1. Besides classical music, are there any other reasons Robert could have had a better score on this test? Explain. _____

   _____

   _____

2. What would you do if you wanted to test whether classical music helps you to study?

   _____

   _____

   _____

Activity A: Experimental investigations

Robert's experiment had an encouraging result, but it did not prove that classical music is helpful. There are many other factors that could affect how well Robert did on his test. For example, the test may have been easier than the previous test. Or Robert may have had an easier time learning the material. Or perhaps Robert studied for a longer period of time.

A scientist must design experiments carefully to determine which factors affect the results. One way to determine if one factor affects something else is to have a control. A control is something that does not include the factor being studied. For example, suppose half the students in Robert's class studied for one hour with classical music, and the other half studied for one hour without any music. In this case, the half without music is the **control group**.

Now suppose that, on average, the people who listened to music improved their test score by 10 points and the people without the music did a little bit worse on the test. This would not prove that classical music helped, but it would be very strong evidence that it did.

An **experimental investigation** is an investigation that is fair because it is controlled. In a **controlled experiment**, only one factor changes for each of the experimental subjects. This factor is called the **manipulated variable**. For example, in Robert's investigation, the manipulated variable is classical music. The other factors (the test, the amount of time studying, etc.) are the same for the **experimental group** (the group with music) and the control group.

Robert's example shows another important aspect of experimental investigations. If the experiment is only done on one student, the results are not very convincing. There are many reasons a person could do better on one test than another. One way to make results more reliable is to increase the **sample size**, or number of observations.

There are two ways to increase the sample size. The first is to increase the number of subjects in the experiment. For example, Robert could run an experiment with 500 or 1,000 students. The second is to increase the number of **trials**, or repetitions of the experiment. For example, Robert could run an experiment with his classmates studying for and taking ten different tests. Increasing the sample size is especially useful when experimental results are highly variable.

1. Linda sees an ad that says Stain Zap stain remover will clean all stains when added to a load of laundry. To test this claim, she prepares two identical shirts with ketchup, mustard, and grass stains. She washes the first shirt with her normal laundry detergent. She washes the second shirt with the same brand of laundry detergent and Stain Zap stain remover.

   A. In Linda's experiment, what is the manipulated variable? _____

   B. Is Linda's experiment a controlled experiment? Explain why or why not. _____

   _____

   _____

2. Brittany wants to know which sunscreen works best. She brings three brands of sunscreen to the beach. Brittany uses Brand A, her friend Jason uses a Brand B, and her other friend Denise uses the Brand C.

While they are at the beach, Brittany sits under an umbrella, Jason goes swimming several times, and Denise sunbathes. At the end of the day, Jason has major sunburn, Denise has slight sunburn, and Brittany has no sunburn.

A. Is this a controlled experiment? Explain why or why not. _____

_____

_____

B. At the end of the day, Brittany claims that Brand A is the best sunscreen. Is this conclusion justified? Explain. _____

_____

_____

C. How could you improve Brittany's experiment? _____

_____

_____

_____

_____

3. Justin and Kelly do similar projects for the science fair. Both test the effects of fertilizer on plant growth. Justin grew one plant with fertilizer and one plant with no fertilizer. He reports that the plant with fertilizer grew slightly taller and bushier than the plant without fertilizer.

Kelly grew 10 plants with fertilizer and 10 plants without fertilizer. Kelly found that the plants with fertilizer had an average mass of 53 grams, while the plants with no fertilizer had an average mass of 45 grams.

If you gave a prize to one of these projects, who would you give it to and why? _____

_____

_____

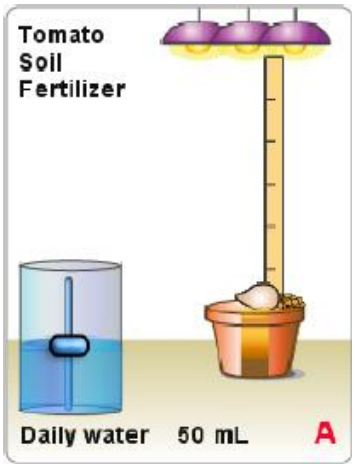
_____

Activity B: Testing fertilizer

The *Growing Plants* Gizmo allows you to change the amount of water and light for three kinds of plants: tomatoes, turnips, and beans. You can also add fertilizer and compost to the pots.

To use the Gizmo, drag seeds to the pots. The amount of light can be controlled by clicking the light bulbs. The sliders on the water containers control how much water each plant receives. If desired, fertilizer and compost can be added to pots.

In the first experiment, you will test the effect of fertilizer on tomato plants.



Question: Does fertilizer help the growth of tomato plants?

1. Hypothesis: How do you expect fertilizer to affect the growth of tomato plants? _____

   _____

2. Set up Gizmo: Drag a **Tomato** seed to each pot. Drag a chunk of **Fertilizer** to pot **C**. Check that each pot has three lights and 50 mL of water. Click **Play** ( ), and wait 50 simulated days for the plants to grow.

3. Record: Record the height and mass of plants **A** and **B** on the left side of the table below, and the height and mass of plant **C** on the right side. Then, click **Reset** ( ) and **Play** to grow a new batch of tomato plants. Continue until you have grown 5 plants with fertilizer and 5 plants with no fertilizer. (You will have to adjust which plants get fertilizer.)

Plants with no fertilizer			Plants with fertilizer		
Trial	**Height**	**Mass**	**Trial**	**Height**	**Mass**
1			1		
2			2		
3			3		
4			4		
5			5		
Mean			**Mean**		

4. Calculate: To find the **mean** height and mass, add up the values for each trial and then divide by 5. Record the mean height and mass on the last line of the table.

   What do you notice about these values? _____

   _____

5. Analyze: What were the lowest and highest values for each category?

Plants with no fertilizer

Lowest height: _____ Lowest mass: _____

Greatest height: _____ Greatest mass: _____

Plants with fertilizer

Lowest height: _____ Lowest mass: _____

Greatest height: _____ Greatest mass: _____

Overall, how much variation did you see in the results? _____

_____

_____

6. Draw conclusions: What was the effect of fertilizer on the growth of tomato plants?

_____

_____

_____

7. Apply: In this experiment, what was the control group? _____

What was the experimental group? _____

What made this investigation a controlled experiment? _____

_____

_____

_____

8. Explain: Why was it important to conduct multiple trials in this experiment? _____

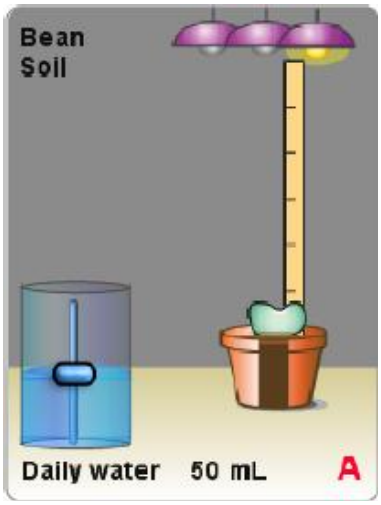
_____

_____

_____

Activity C: Design your own Gizmo experiment

Click **Reset** and **Clear pots**. The *Growing Plants* Gizmo allows you to experiment with light, water, compost, and fertilizer for three kinds of plants. In this activity, you will ask a question, create a hypothesis, and then use the Gizmo to design a controlled experiment to test your hypothesis.



Use the template below to record your question, hypothesis, procedure, data/observations, and conclusions. Create a table to record your data. Be sure to use multiple trials. Analyze your data by calculating means. Analyze the variation in your data as well.

After you have written your conclusions, answer the follow-up questions.

Question: _____

_____

Hypothesis: _____

_____

Procedure: _____

_____

_____

_____

Data and Observations:

Analysis:

Conclusions: _____

_____

_____

_____

_____

Follow-up questions

1. In your experiment, what was the manipulated variable? _____

2. Did your experiment have a control group? If so, what was the control group? _____

   _____

3. How do you know your experiment was a controlled experiment? _____

   _____

   _____

   _____

4. Why is it important to conduct multiple trials? _____

   _____

   _____

   _____

Activity D: Design your own plant experiment

The *Growing Plants* Gizmo gives you all the background you need to design your own experiment with real growing plants.

Begin by asking a question. The question should be as specific as possible, such as “How does fertilizer affect the growth of tomato plants?”

Your question should be something that can reasonably answered in the experiment you do. “Can tomato plants grow on Venus?” is an example of a question you probably won’t be able to tackle in this experiment.

Next, write a hypothesis to answer your question and design an experiment to test your hypothesis. Recall that multiple trials will increase the reliability of any results you get, so think about growing several plants in each trial. Think carefully about how you will make observations and collect data. For example, will you measure the growth of plants by measuring their height, measuring their mass, or some other method? Will you make other observations, such as the color and number of leaves?

Use the template below to guide your experiment. You will probably need to use additional pages to write all of your procedures, data, and observations. When the experiment is complete, answer the follow-up questions on the next page.

Question: _____

_____

Hypothesis: _____

_____

Procedure: _____

_____

_____

_____

Data and Observations:

Analysis:

Conclusions: _____

_____

_____

_____

_____

Follow-up questions

1. In your experiment, what was the manipulated variable? _____

2. Did your experiment have a control group? If so, what was the control group? _____

   _____

3. How do you know your experiment was a controlled experiment? _____

   _____

   _____

   _____

4. Why is it important to conduct multiple trials? _____

   _____

   _____

   _____